AD-A009 473

POWERING PREDICTIONS FOR THE UNITED STATES COAST GUARD
140-FOOT WYTM REPRESENTED BY MODEL 5336

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(U) This report presents powering predictions for a WYTM with stock propellers. This hull can attain a speed of 14.6 knots in smooth deep, fresh water. A slight increase should be attained with design propellers.

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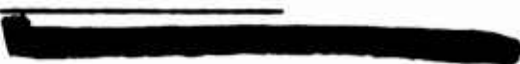
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INTRODUCTION

The United States Coast Guard (USCG) initiated a model experimental program at the Naval Ship Research and Development Center (NSRDC) to aid in the evaluation of a proposed design for a 140-foot WYTM with icebreaking capabilities. In this program NSRDC was requested to provide the following:

(1)   Shaft horsepower (P_S), effective horsepower (P_E), RPM and allied data for the hull with rudder.

(2) P_S and RPM for the towrope and bollard pull conditions.

(3)   Flow patterns about the underwater portion of the hull and rudder.

(4)   Velocity distribution in way of the propeller and its harmonic analysis.

(5)   Maneuvering and directional stability.

This report covers Items (1) and (2). Data for Items (3), (4), and (5) of the program will be issued in subsequent reports.

PROCEDURE AND EXPERIMENTAL RESULTS

Model 5336 represents a 140-foot WYTM icebreaker constructed in accordance with USCG lines and offsets No. 140 WYTM-0101-1 dated 14 August 1974. A linear ratio of 9.273 was selected so that a 4-bladed stock propeller with a nominal diameter of 11 inches could be used in the powering phase of this program. Additional ship and model data along with hull characteristics are given in Figure 1. Abbreviated hull lines of the WYTM are shown in Figure 2. Fitting room photographs of the model are displayed in Figure 3.

Predictions of P_E, P_S and allied data resulting from the propulsion experiment at the design draft corresponding to 12 feet, trimmed to a level baseline, and a displacement of 666 tons are tabulated in Table 1. The tables are copies of computer output sheets. In this computer program some of the final values are rounded off. The P_E, P_S, RPM and η_S (P_E/P_S) are presented graphically in Figure 4. These data show that when fitted with an 8.5-foot prototype of NSRDC Stock Propeller 4665, the WYTM will attain a speed of about 14.6 knots using 2500 shaft horsepower.

Table 2 gives predictions for P_S and allied data tabulated for the WYTM at the 11-foot draft, even baseline. The P_E, P_S, RPM and η_S are also shown graphically in Figure 5.

All powering predictions reported herein are for the ship operating in smooth, deep, fresh water with a temperature of 40 degrees Fahrenheit. A correlation allowance (C_A) of 0.0004 and the ITTC friction formulation of 1957 were used in all frictional calculations. The open-water characteristic curves for NSRDC Stock Propeller 4665 are shown in Figure 6. Tabulated open-water data are given in Table 3.

Change of level data taken during various experiments are shown in Figure 7. The wave profiles for 10 and 15 knots are shown graphically in Figure 8 for the 12-foot draft condition. Wave profile photographs taken during Experiment 5, the 12-foot draft condition, are shown in Figure 9.

Predictions of P_S and RPM requirements for towrope pull conditions are shown in Figure 10. The speeds covered in the ahead operation are zero (bollard pull), 3, and 6 knots. The predictions for the bollard pull astern operation are given in Figure 11.

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TABLE 1

PREDICTIONS OF SHP, RPM AND ALLIED DATA FOR THE 140-FOOT WYTM REPRESENTED BY MODEL 5336 WITH PROPELLER 4665

EXPERIMENTS 4 & 5   DISPLACEMENT 666 TONS   DRAFT 12.0 FT - EVEN BASELINE

CORRELATION ALLOWANCE 0.0004   PROPELLER DIAMETER 8.5 FT

V_S	P_E	P_S	RPM	η_S	$1-W_T$	J_T	$1-W_Q$	$1-t$	η_P	η_H	η_R
5.00	20.	35.	81.9	.565	.745	.540	.755	.810	.505	1.090	1.020
6.00	34.	60.	97.9	.565	.740	.540	.750	.810	.505	1.095	1.020
7.00	56.	99.	115.0	.565	.740	.535	.750	.810	.505	1.095	1.015
8.00	88.	156.	132.6	.565	.740	.530	.745	.810	.510	1.100	1.015
9.00	129.	228.	149.9	.565	.735	.525	.740	.810	.510	1.100	1.010
9.50	154.	272.	158.7	.565	.735	.525	.740	.810	.510	1.100	1.010
10.00	189.	334.	169.0	.565	.735	.520	.740	.810	.505	1.100	1.010
10.50	251.	445.	183.9	.565	.740	.500	.750	.810	.505	1.100	1.020
11.00	319.	567.	198.1	.565	.740	.490	.760	.810	.500	1.090	1.030
11.50	389.	697.	211.4	.560	.750	.485	.765	.810	.500	1.085	1.030
12.00	460.	833.	223.5	.550	.750	.480	.770	.810	.500	1.075	1.030
12.50	536.	986.	235.1	.545	.755	.480	.765	.810	.495	1.075	1.020
13.00	621.	1160.	246.4	.535	.755	.475	.760	.810	.495	1.075	1.005
13.50	747.	1410.	261.4	.530	.755	.465	.760	.810	.495	1.070	1.005
14.00	932.	1780.	280.2	.525	.760	.450	.765	.810	.485	1.065	1.010
14.50	1190.	2300.	302.8	.515	.765	.435	.780	.810	.480	1.060	1.020
15.00	1530.	3050.	328.9	.500	.770	.420	.790	.810	.465	1.050	1.020
15.50	1970.	4070.	358.2	.485	.780	.400	.800	.810	.455	1.040	1.020
16.00	2550.	5490.	391.4	.465	.785	.380	.810	.810	.440	1.030	1.020
16.50	3280.	7410.	427.3	.445	.790	.365	.810	.810	.425	1.025	1.015
17.00	4130.	10080.	463.9	.410	.800	.350	.770	.810	.415	1.010	0.980

TABLE 2

PREDICTIONS OF SHP, RPM AND ALLIED DATA FOR THE 140-FOOT WYTM
FULLY APPENDED REPRESENTED BY MODEL 5305 WITH PROPELLER 4665

EXPERIMENTS 6 & 7   DISPLACEMENT .581 TONS   DRAFT 11.0 FT EVEN BASELINE

CORRELATION ALLOWANCE 0.0004   PROPELLER DIAMETER 8.5 FT

V_S	P_E	P_S	RPM	η_S	$1-w_T$	J_T	$1-w_Q$	$1-t$	η_P	η_H	η_R
5.00	20.	33.	82.2	.600	.755	.545	.795	.820	.505	1.085	1.090
6.00	34.	56.	98.4	.600	.755	.550	.790	.820	.505	1.090	1.090
7.00	54.	89.	114.6	.600	.750	.545	.790	.820	.505	1.090	1.085
8.00	82.	137.	131.5	.600	.750	.545	.785	.820	.505	1.095	1.080
9.00	124.	207.	149.6	.600	.745	.535	.780	.820	.510	1.100	1.075
9.50	153.	256.	159.3	.600	.745	.530	.780	.820	.510	1.100	1.070
10.00	191.	321.	170.1	.595	.745	.520	.775	.820	.505	1.100	1.065
10.50	240.	410.	182.3	.585	.745	.510	.775	.820	.505	1.100	1.055
11.00	308.	530.	196.7	.580	.750	.500	.780	.820	.505	1.095	1.050
11.50	370.	648.	209.4	.570	.760	.495	.790	.820	.505	1.080	1.050
12.00	434.	772.	220.1	.560	.755	.490	.780	.820	.500	1.085	1.035
12.50	504.	909.	231.3	.555	.760	.490	.775	.820	.500	1.080	1.025
13.00	593.	1090.	243.7	.545	.760	.485	.770	.820	.500	1.075	1.010
13.50	722.	1350.	259.8	.535	.765	.475	.775	.820	.495	1.065	1.010
14.00	901	1710.	278.7	.525	.770	.460	.780	.815	.490	1.060	1.015
14.50	1140.	2210.	300.9	.515	.775	.445	.795	.815	.485	1.045	1.025
15.00	1480.	2930.	327.4	.505	.780	.425	.810	.810	.470	1.035	1.030
15.50	1920.	3960.	357.8	.485	.790	.405	.820	.805	.460	1.020	1.035
16.00	2470.	5320.	390.0	.465	.795	.390	.830	.800	.445	1.010	1.035
16.50	3140.	7060.	421.7	.445	.790	.365	.810	.800	.430	1.015	1.020
17.00	3890.	9260.	457.7	.420	.805	.355	.820	.795	.420	.990	1.015

TABLE 3

FAIRED OPEN WATER CHARACTERISTICS

PROPELLER 4665   TEST 2

J	K_T	$10K_Q$	η_0
.000	.284	.342	.000
.050	.268	.322	.066
.100	.251	.304	.132
.150	.234	.286	.195
.200	.217	.269	.257
.250	.199	.252	.314
.300	.181	.235	.367
.350	.162	.217	.415
.400	.142	.199	.455
.450	.122	.181	.485
.500	.102	.151	.504
.550	.081	.140	.505
.600	.059	.118	.478
.650	.037	.094	.404
.700	.014	.068	.225
.730	0.000	.052	0.000

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SHIP AND MODEL DATA
MODEL 5336

BARE HULL. DENSITY RATIO = 1.001756 AT 40 DEG. FW FOR THE SHIP

	SHIP	MODEL		
WL LENGTH (LWL) FT	130.0	14.02	LINEAR RATIO =	9.273
LENGTH AP (LPP) FT	130.0	14.02	V/SQRT(LWL) =	1.316
BEAM AT AX (BX) FT	34.2	3.68	CIRCLE K =	2.960
DRAFT AT AX (TX) FT	12.0	1.30	CIRCLE P =	1.274
DISPLACEMENT(DIS)TONS	666. FW	.83FW	XFB/LWL =	.518
	LBS		XFB/LPP =	.518
	1868.9		XFF/LWL =	.514
WETTED SURF. (S)SQ FT	4460.	51.87	1/2 ENT.ANGLE= 27.0 DEG	
DESIGN SPEED (V) KTS	15.0	4.93		

LWL COEFFICIENTS

CB = .447	CPE = .59	LF/L = .55
CP = .593	CPR = .60	LP/L = 0.00
CX = .754	CVP = .62	LR/L = .45
CWP = .717	CVPA = .63	L/BX = 3.80
CPF = .55	CVPF = .62	BX/TX = 2.84
CPA = .55	CWF = .68	D-L =303.28
	CWA = .76	CWS = 15.15

LPP COEFFICIENTS

CB =	.451
CP =	.600
L/BX =	3.80
D-L =	303.28
FTE =	0.00
TTE =	.16

****

FWD STATIONS

0.00	.50	1.00	1.50	2.00	2.50	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
A/AX													
0.000	.010	.038	.083	.147	.227	.304	.458	.602	.729	.831	.906	.955	.988
B/BX													
0.000	.104	.203	.298	.387	.468	.541	.670	.775	.856	.916	.957	.982	.996

AFT STATIONS

11.00	12.00	13.00	14.00	15.00	16.00	17.00	17.50	18.00	18.50	19.00	19.50	20.00
A/AX												
1.000	.993	.963	.899	.782	.614	.412	.306	.202	.110	.034	.010	0.000
B/BX												
1.000	.996	.982	.950	.885	.787	.650	.568	.480	.378	.269	.152	.029

FIGURE 1 8
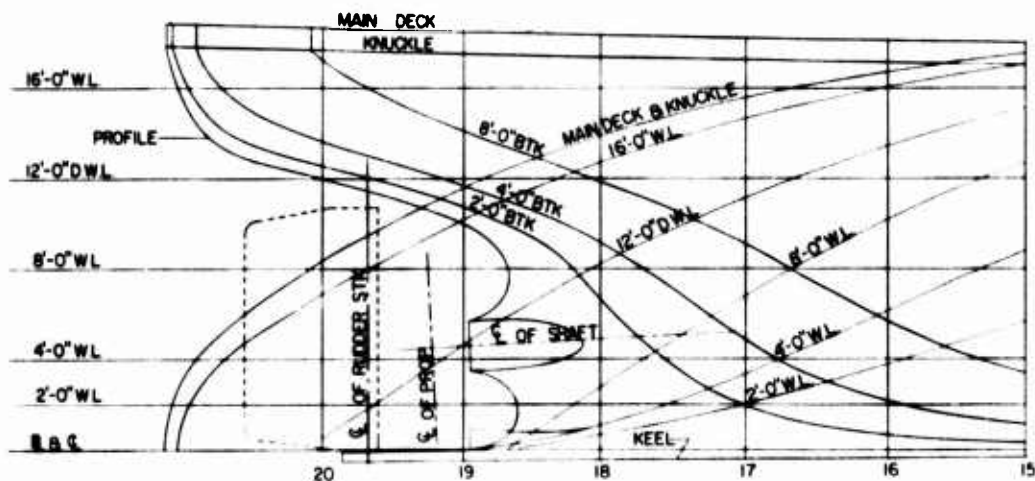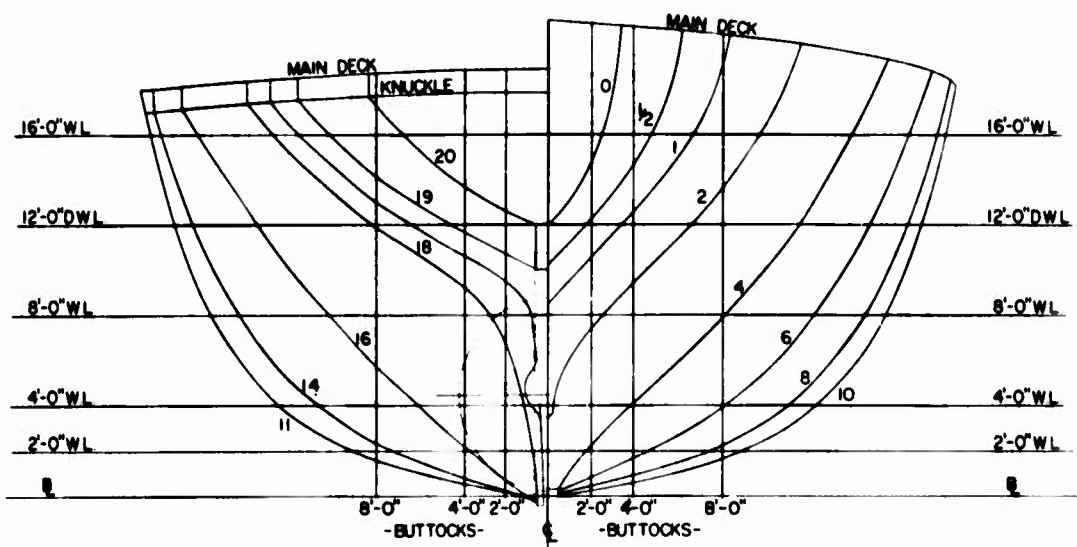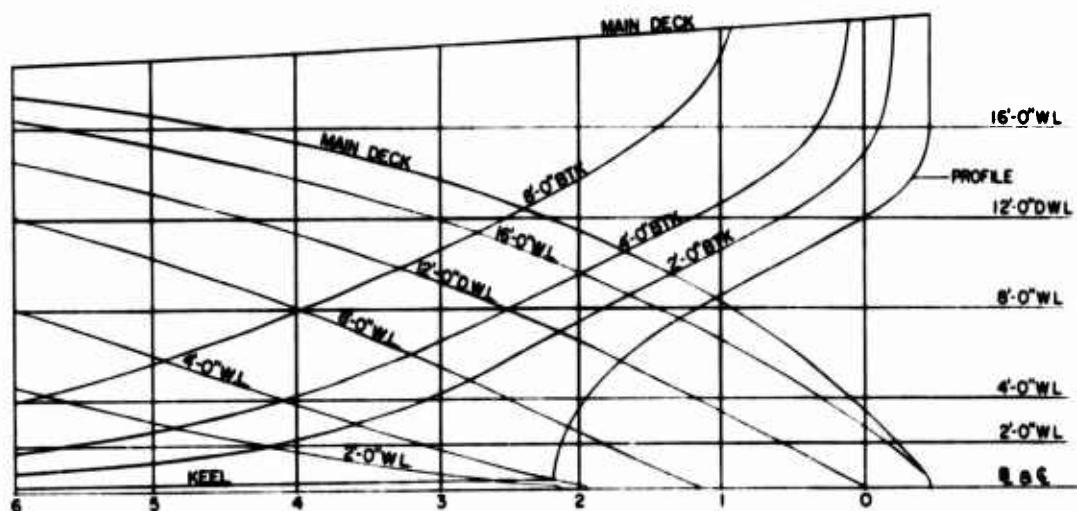
ABBREVIATED LINES AND BODY PLAN
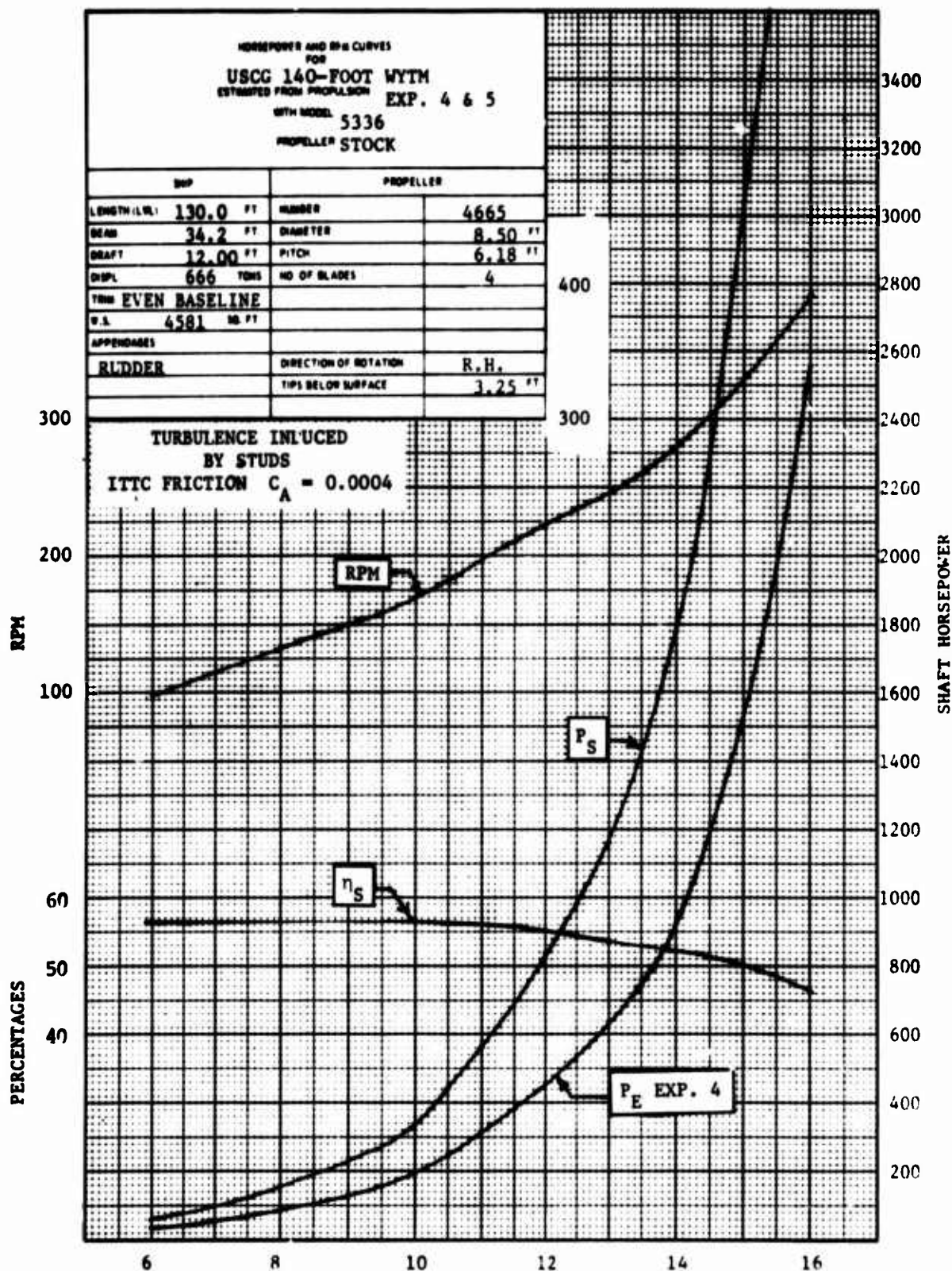OF UNITED STATES COAST GUARD 140-FOOT WYTM

FIGURE 2

FITTING ROOM PHOTOGRAPHS OF MODEL 5336 REPRESENTING

THE UNITED STATES COAST GUARD 140-FOOT WYTM

FIGURE 3

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HORSEPOWER AND RPM CURVES
FOR
USCG 140-FOOT WYTM
ESTIMATED FROM PROPULSION EXP. 4 6 5
WITH MODEL 5336
PROPELLER STOCK

SHIP		PROPELLER	
LENGTH (LWL)	130.0 FT	NUMBER	4665
BEAM	34.2 FT	DIAMETER	8.50 FT
DRAFT	12.00 FT	PITCH	6.18 FT
DISPL	666 TONS	NO OF BLADES	4
TRIM EVEN BASELINE			
W.S. 4581 SQ. FT			
APPENDAGES			
RUDDER		DIRECTION OF ROTATION	R.H.
		TIPS BELOW SURFACE	3.25 FT

TURBULENCE INDUCED
BY STUDS
ITTC FRICTION $C_A = 0.0004$
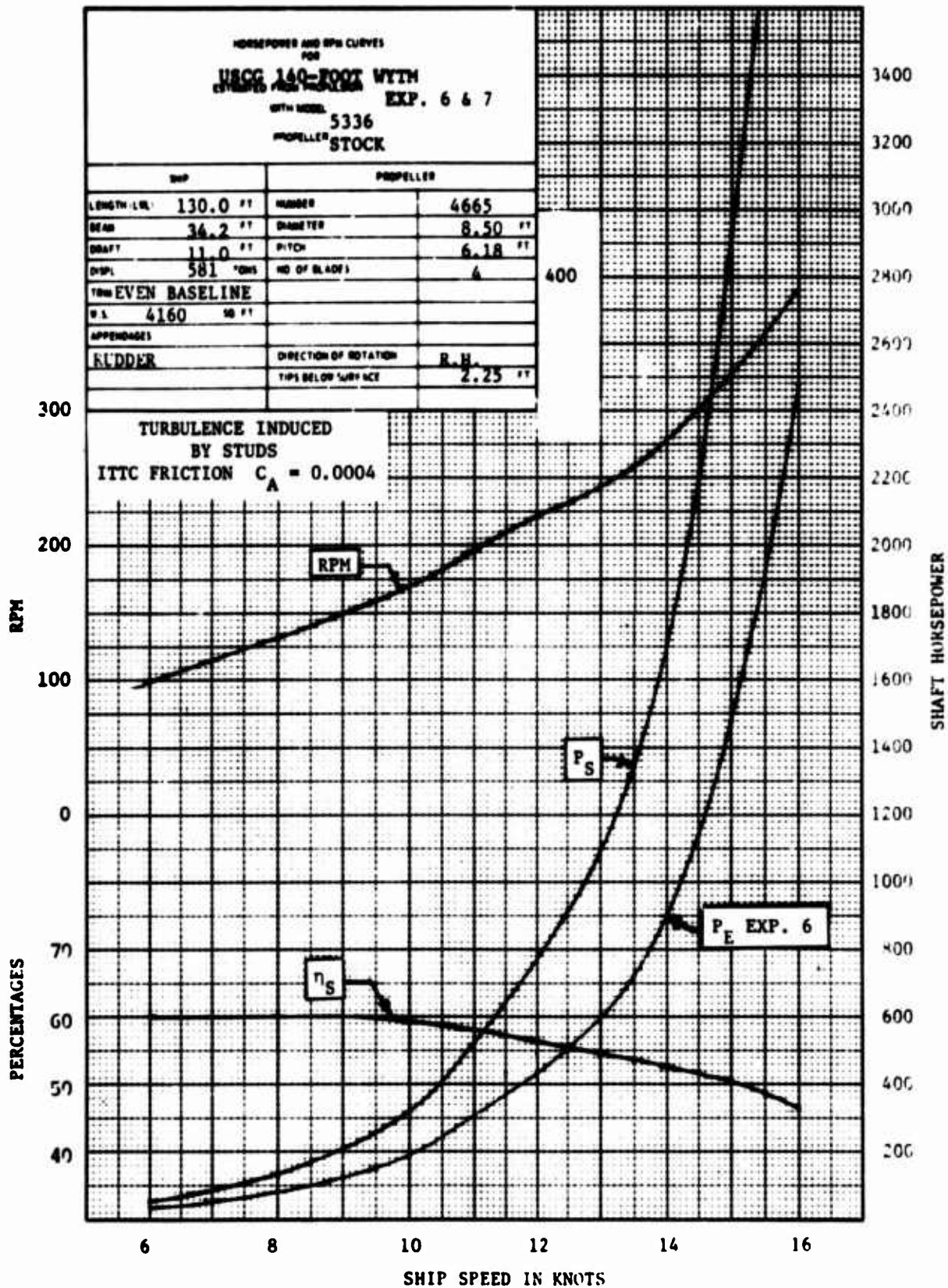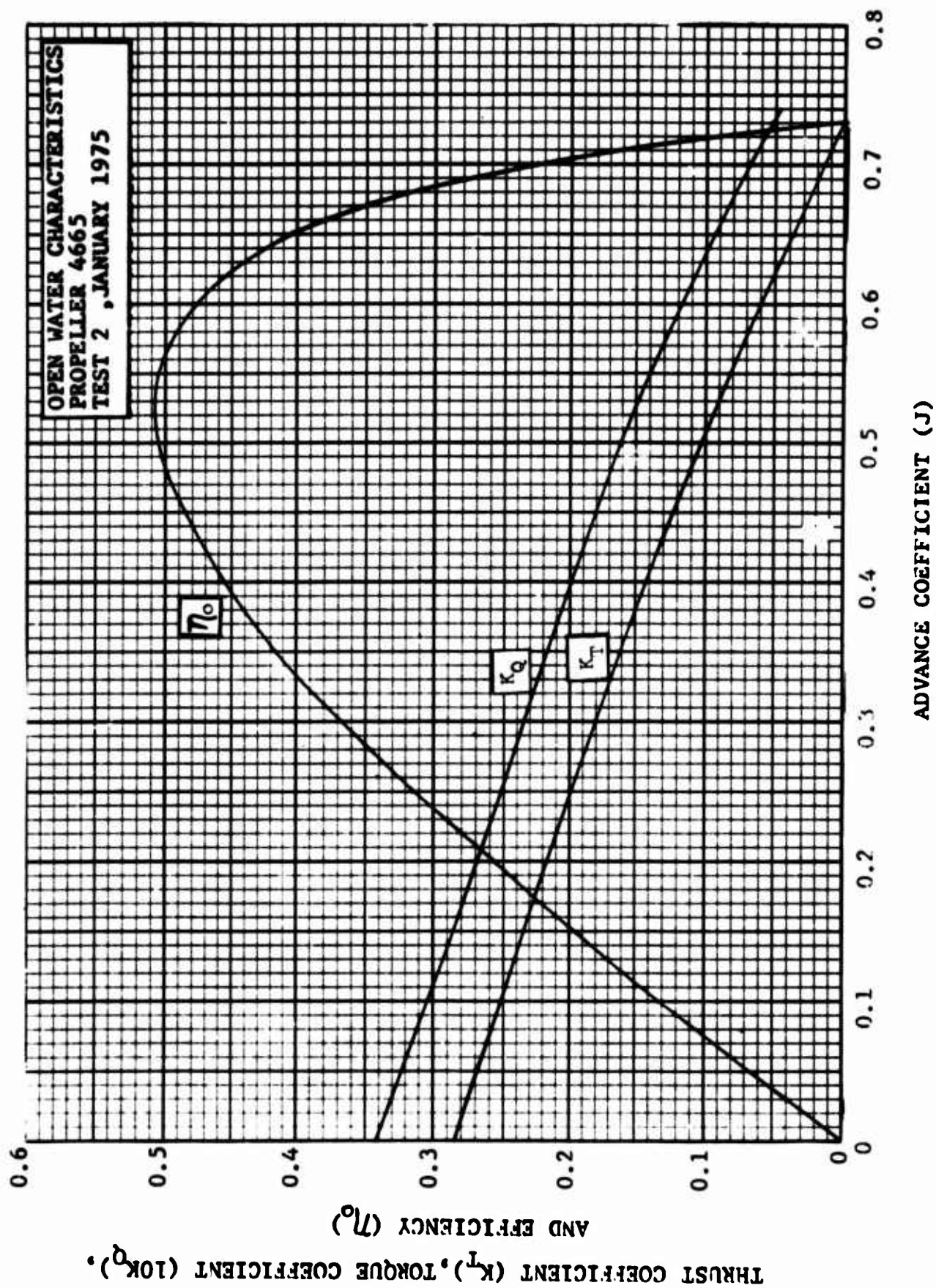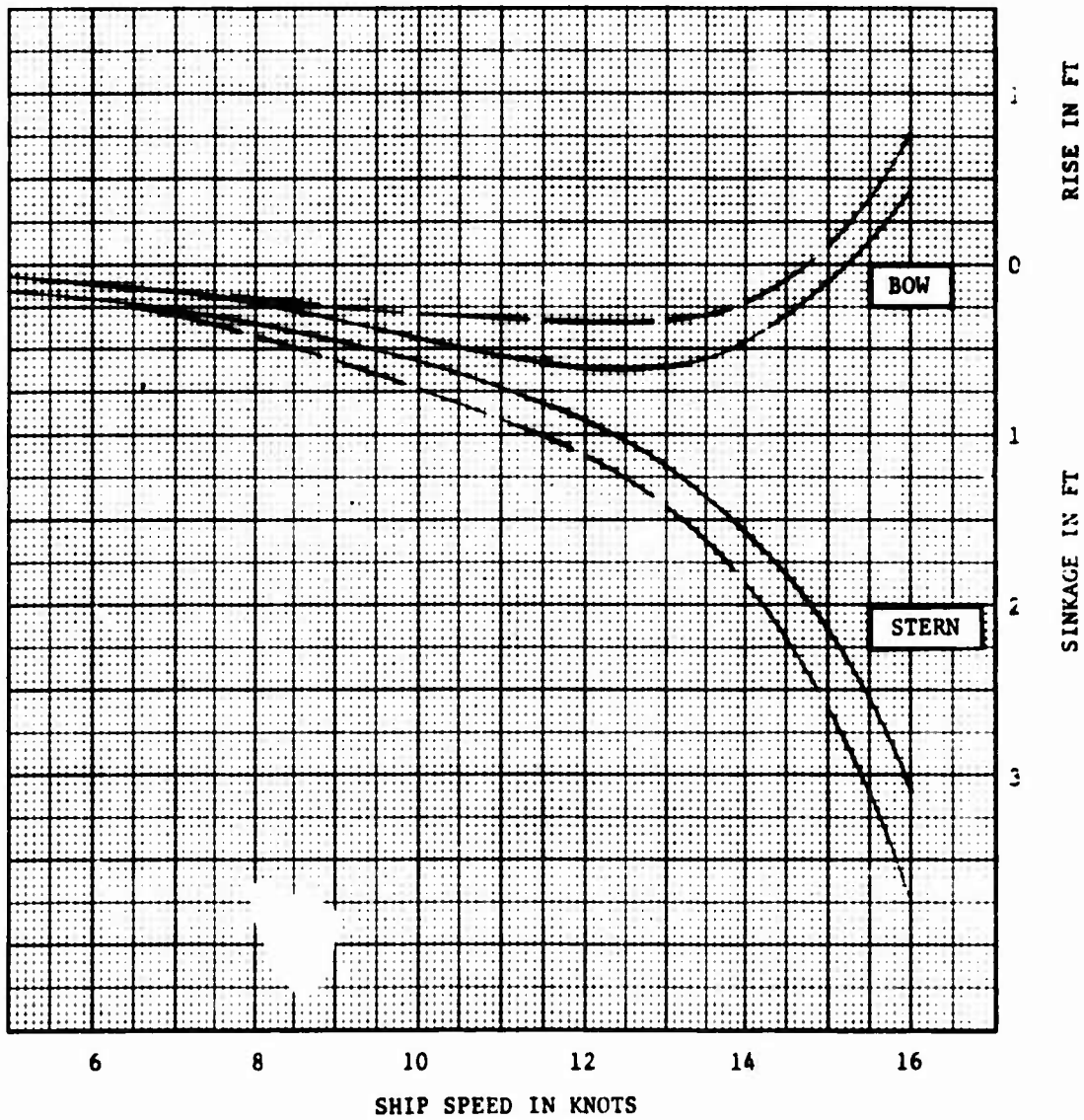
SHIP SPEED IN KNOTS
FIGURE 4

//

FIGURE 5

FIGURE 6

CHANGE OF LEVEL CURVES

FOR

USCG 140-FOOT WYTM

REPRESENTED BY MODEL 5336

EXPERIMENT	DISPLACEMENT	DRAFT	TRIM	
4 & 5	666 TONS	12 FT	EVEN BASELINE	——————
6 & 7	581 TONS	11 FT	EVEN BASELINE	——— — ———

SHIP SPEED IN KNOTS

FIGURE 7

WAVE PROFILE

USCG 140-FT WITH
REPRESENTED BY MODEL 5336

DISPLACEMENT   666 TONS
DRAFT 12 FT EVEN BASELINE

WAVE PROFILE AT 15 KNOTS
WAVE PROFILE AT 10 KNOTS

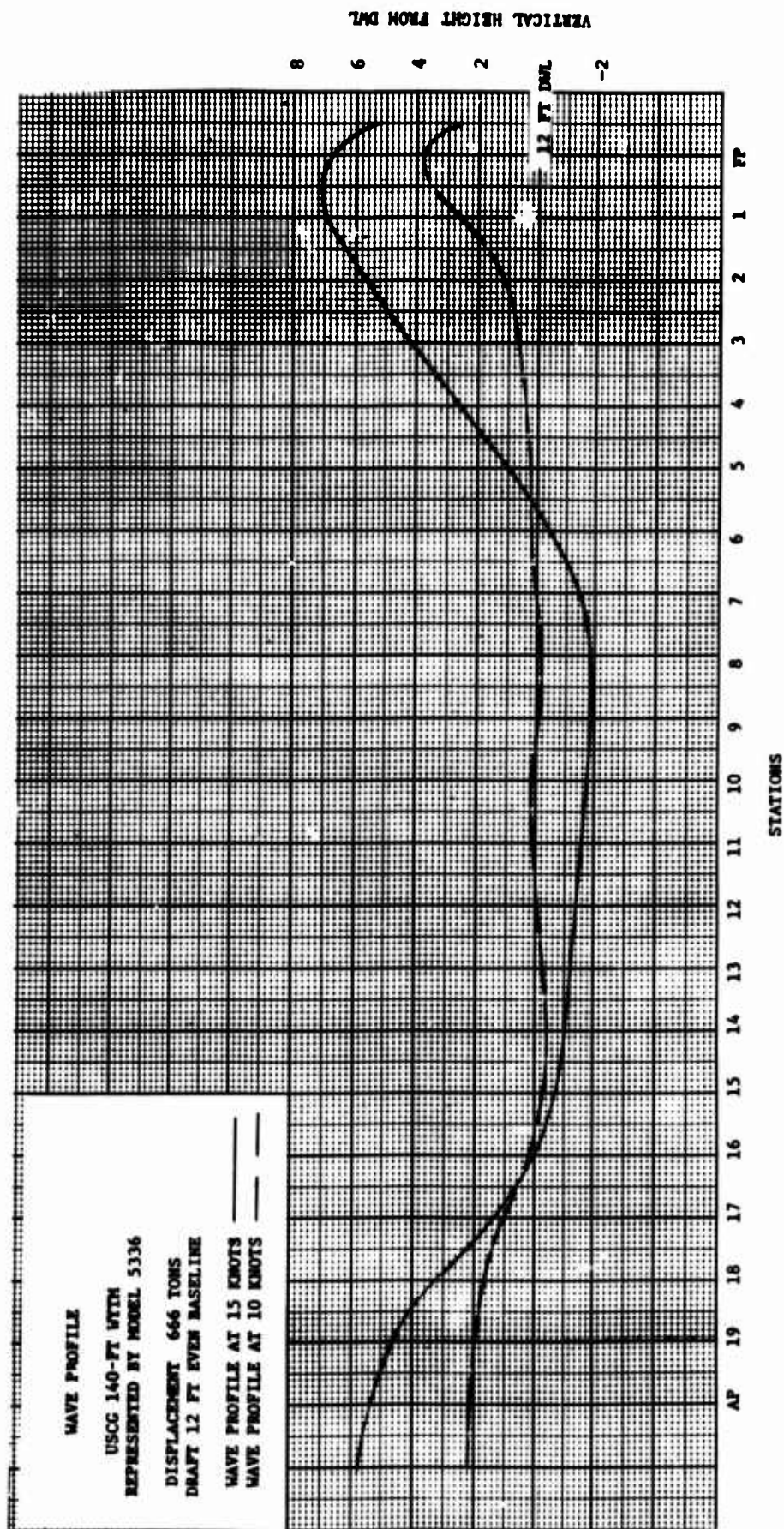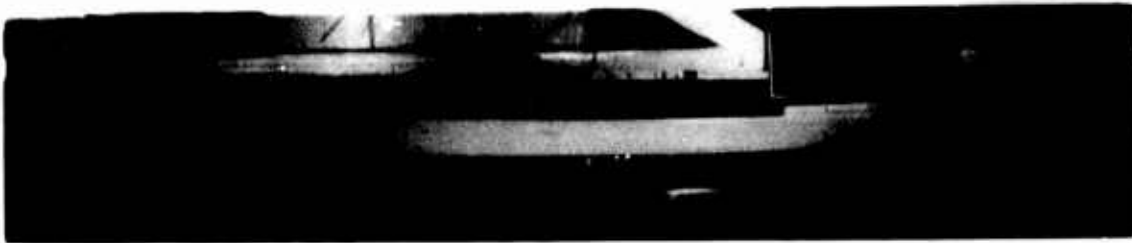VERTICAL HEIGHT FROM DWL

STATIONS

FIGURE 8

15

PSD   342337

PSD   342336

PSD   342340

PSD   342338

PSD   342339

WAVE PROFILE PHOTOGRAPHS OF MODEL 5336 REPRESENTING
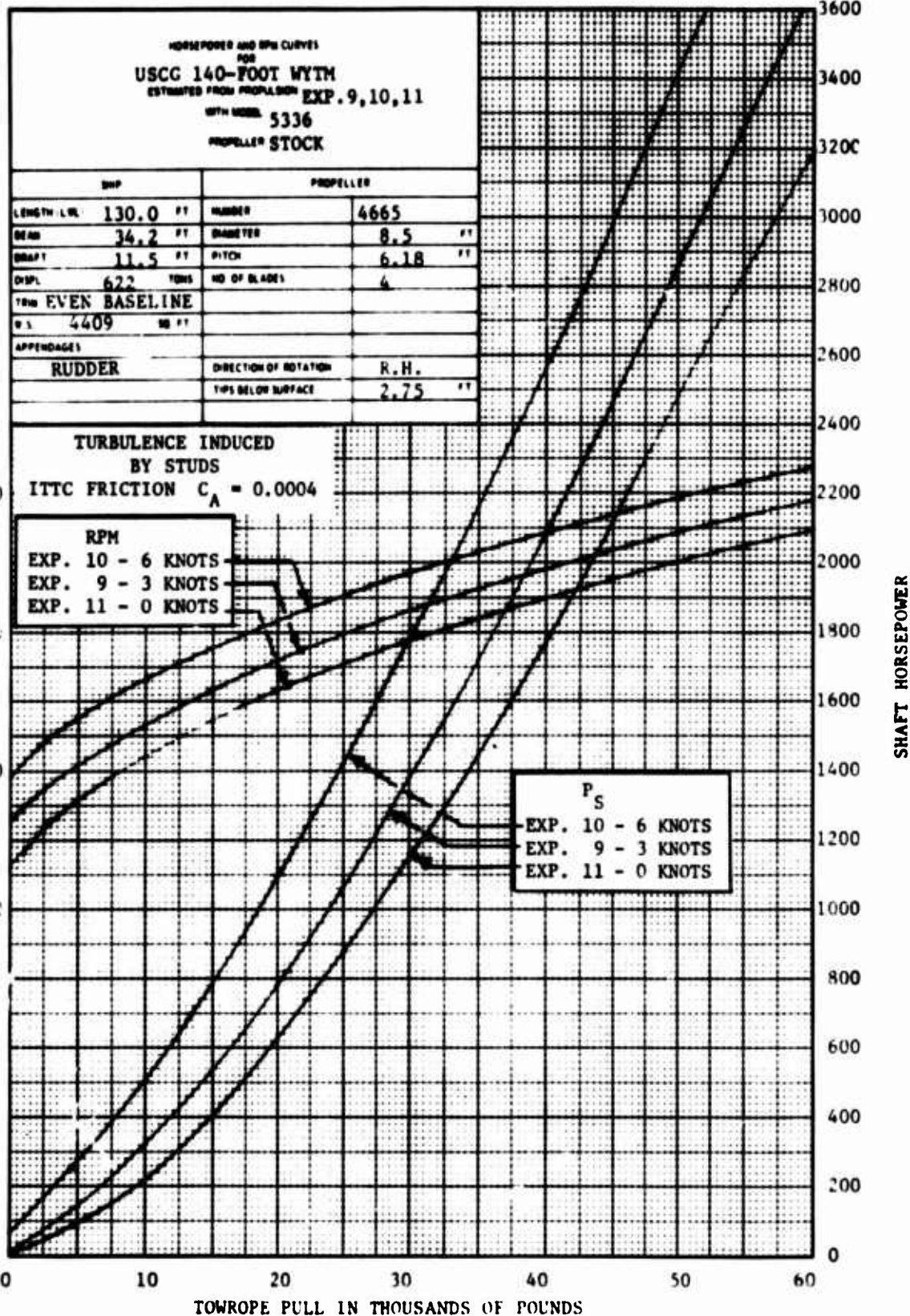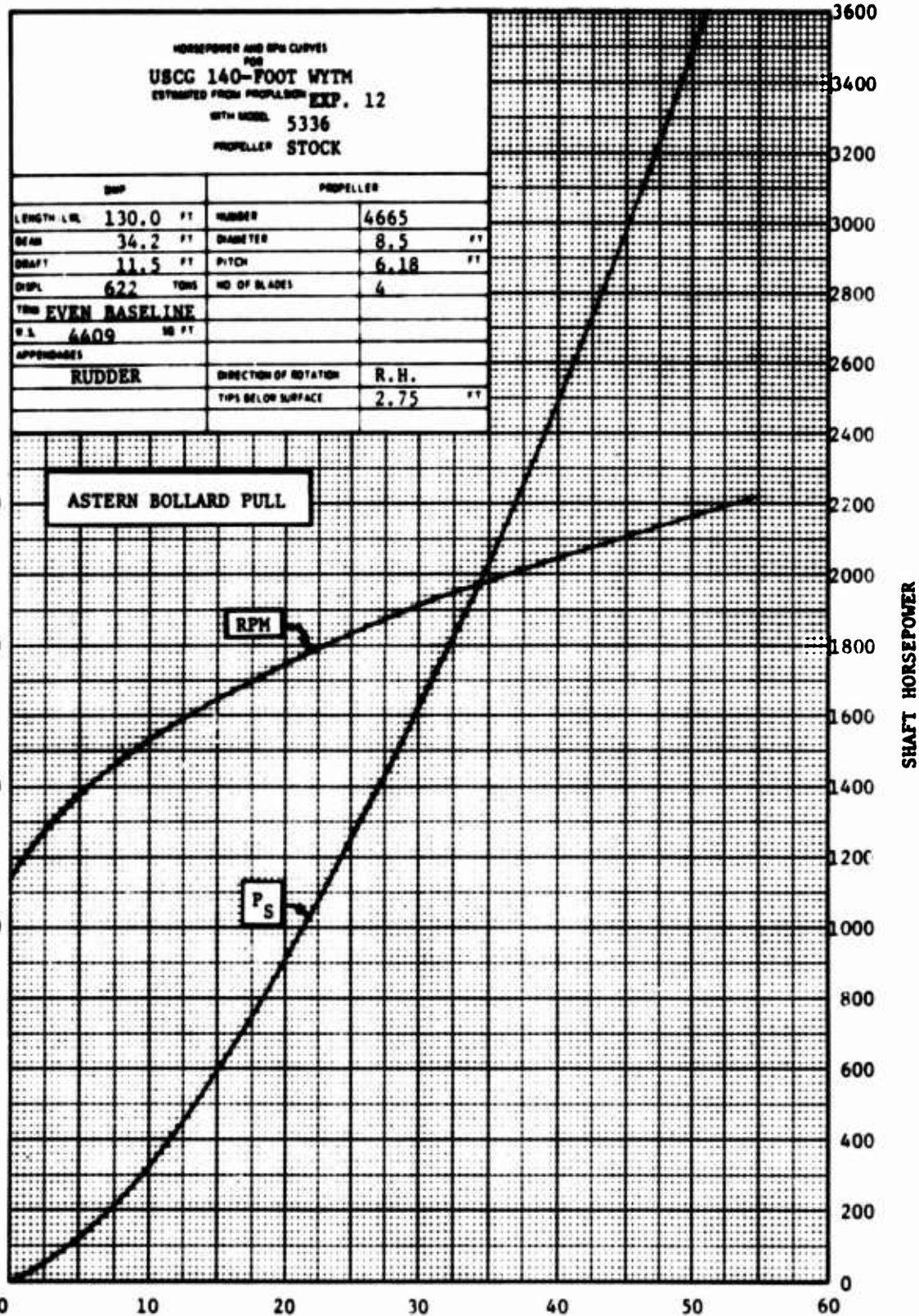THE UNITED STATES COAST GUARD 140-FOOT WYTM

FIGURE 9

FIGURE 10

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HORSEPOWER AND RPM CURVES
FOR
USCG 140-FOOT WYTM
ESTIMATED FROM PROPULSION **EXP. 12**
WITH MODEL **5336**
PROPELLER **STOCK**

SHIP			PROPELLER		
LENGTH L.W.L	130.0	FT	NUMBER	4665	
BEAM	34.2	FT	DIAMETER	8.5	FT
DRAFT	11.5	FT	PITCH	6.18	FT
DISPL	622	TONS	NO. OF BLADES	4	
TRIM **EVEN BASELINE**					
W.S.	4609	SQ FT			
APPENDAGES					
RUDDER			DIRECTION OF ROTATION	R.H.	
			TIPS BELOW SURFACE	2.75	FT

ASTERN BOLLARD PULL

ASTERN BOLLARD PULL IN THOUSANDS OF POUNDS
FIGURE 11

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